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BOTANY.

Yucca Pollination.—Probably the most interesting case of insect pollination known is that of *Yucca* by the little moth *Pronuba*. Under the title, "Yucca Moth and Yucca Pollination,"[1] Dr. C. V. Riley has lately summarized the results of observations and investigations on this interesting subject. Having myself verified many of the observations detailed, I have consented, at Dr. Bessey's request, to outline the process of pollination as at present understood, for the NATURALIST.

Dr. Geo. Englemann[2] was evidently the first observer to notice the Yucca moth and suspect its relation to the pollination of *Yucca*. Specimens of the moth were sent to Dr. Riley who christened it *Pronuba yuccasella*[3], and took up the investigation of the subject obtaining surprising results. The subject has since been much studied but to Drs. Riley and Trelease we are chiefly indebted for its development.

Self fertilization in *Yucca* is practically impossible. The stamens curve away from the pistil, in several cases very strongly, thus placing the pollen at some distance from the pistil. The pollen furthermore is glutinous and not easily detached and blown about; and the three lobes of the stigma are erect and so arranged that pollen dropping cannot fall into the stigmatic tube into which, it is further found, the pollen must be inserted some distance to be effective. Thus *Yucca* is entirely dependent on outside aid for pollination. Few species of plants, if any, depend upon one species of insect for pollination. Many have very numerous pollinators. Yuccas, however, appear to be actually dependent upon some one species of the little moth *Pronuba*. All species of *Yucca* east of the Rocky Mountains are apparently dependent upon *Pronuba yuccasella*.

[1] Third Annual Report Missouri Botanical Garden, 1892, pp. 99–158, 10 plates.—The reader is referred to this article for all details. The life history of *Pronuba* and *Prodoxus* (the bogus Yucca moth) is discussed, and descriptions of all known species are appended. Several species are described as new.

[2] "The Flower of Yucca and its Fertilization," Bull. Torr. Bot. Club, vol. iii, no. 7 (July, 1872), and "Notes on the Genus Yucca," Trans. Acad. Sci. of St. Louis, vol. iii, No. 1 (April, 1873).

[3] "On a new Genus in the Lepidopterous Family Tineidæ, with Remarks on the Fertilization of Yucca," Trans. Acad. Sci. of St. Louis, vol. iii, No. 1, p. 55 (April, 1873).

Pronuba is not attracted to the flower by nectar. As Trelease has shown,[4] large nectaries are present in Yucca, but frequently little nectar is produced. It is questionable whether that produced is ever utilized by *Pronuba* as she has never been observed to feed. This, as Riley observes, " adds to the importance of *Pronuba* by showing that the acts of collecting pollen and transferring it to the stigma do not result in food compensation." The eggs of *Pronuba* are deposited in the young Yucca capsule at this time and fertilization is necessary in order that the larvæ which feed on the maturing seeds may develop. Thus *Pronuba* insures the development of the seeds by pollinating the plant and is compensated by having her larvæ provided for, so far as food is concerned.

During the day the moth may be found in the flowers where they remain, their white color, being the same as the flower, protecting them. In early evening they begin their work. The males are stronger of wing and flit back and forth among the flowers. The female has a work to perform and she loses no time in frolic. Hers is the work of ovipositing and Yucca pollinating. It is surprising with what deftness, accuracy and understanding she proceeds about her task. She first begins by collecting a load of pollen, a stage difficult to observe but now authenticated by many observers. She may be seen quickly running to the top of the stamen, where she pauses, and bending her head down over the anther, with her tongue and maxillary palpi (wonderfully modified for this purpose) extended on the opposite side of the anther, she scrapes the pollen from the anther sacs, and with the aid of her front legs, shapes the gathered pollen into a little ball. She proceeds from anther to anther till a relatively large load is collected, often thrice as large as her head. With this, Riley observes, she flies to another flower usually before ovipositing. I have never observed the gathering of pollen but I have frequently seen the same moth pass from flower to flower and from plant to plant, ovipositing and pollinating in many ovaries without stopping to collect more pollen. In this way cross pollination, in most cases, must surely result.

Equipped with her load of pollen, *Pronuba* proceeds to the further work of oviposition. She enters a flower and may be seen frequently for several minutes resting with the head toward the base of the flower, feeling around with the tentacles or slowly crawling around. Suddenly she awakens and with surprising activity runs rapidly around in the flower over the stamens and finally, in a few seconds, takes position for ovipositing, with the head usually toward the stigma backing down a little, with the body between two of the stamens, her legs straddling them. When a favorable point is found, which is generally slightly below the middle of the ovary, she rests for a short time, then raising the body slightly, thrusts the lance-like ovipositor into the soft tissue of the young ovary, penetrating into an ovarian cavity, where it is retained for a short time while the egg is being deposited. The ovipositor and oviduct are beautifully modified for this purpose. Oviposition only takes place in newly opened flowers, the first or second night after opening, the ovary usually being susceptible to fertilization only during these nights. The moth seems instinctively aware of this and never oviposits in an old flower. She evidently in running about the flower before oviposition, as explained above, seeks and learns whether the flower is in a receptive stage and whether it has been already punctured.

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[4] "The Nectary of Yucca," Bull. Torr. Bot. Club, vol. xiii (August, 1886), p. 135.

No sooner is oviposition completed than the moth proceeds to the act of pollination. She runs to the top of the pistil and bending over the stigma, works her head rapidly up and down, forcibly thrusting the pollen down into the stigmatic tube. The act of oviposition is usually followed by the act of pollination. This occurs so regularly and promptly that, as Trelease expresses it, " the moth seems to have it on her mind to perform the latter as a sequel to the former." When more than one egg is deposited in the same pistil it is thus pollinated more than once, and in some cases where as many as a dozen or more eggs are deposited in the same pistil pollination must be very profuse. There is a necessity for an abundance of pollen, however, as each of the three cells of the ovary contains hundreds of ovules. When the load of pollen is exhausted the moth has been observed to replenish her supply.

The larva of *Pronuba* in its development uses up only from 10–12 seeds, so even in those capsules where the most abundant larvæ develop, hundreds of good seeds are nevertheless produced. The few seeds destroyed may well be sacrificed to insure the pollination and development of the others.

About the time the pod begins to harden the full-grown larva bores its way out, makes its way to the ground, where after boring several inches below the surface it forms its silken cocoon. The larva transforms to the imago state a few days before the flowering of the Yuccas, and makes its way to the surface, where the moth escapes.

The interdependence of Yucca and *Pronuba* is thus seen to be very marked. It is a mutual relationship closely approaching that of symbiosis. The beauty and perfectness of adaptation is, however, yet more marked than I have outlined. Prof. Riley observes that Yuccas are very irregular in flowering, that a plant which flowers this year may not next year. This irregularity might prove fatal to *Pronuba*, but a beautiful device is found to meet it. Yucca moths are equally irregular, a large percentage of the moths failing to issue the year following oviposition, but are retarded until the second, third or fourth years after oviposition.

What is the meaning of the phenomena here observed? We are dealing, it is seen, with a case of pollination widely different from other known cases. In the most highly specialized protandrous flowers as in *Impatiens*, pollination by an insect or humming bird is entirely accidental. In the protogynous flowers of *Aristolochia* and *Arum*, so much admired for their beautiful device for securing cross pollination, carrying the pollen is an entirely unintentional action on the part of the gnats and flies, they going merely where they are allured. In the most perfect device of the many beautiful ones in orchids, the pollinia merely accidentally adhere to the insect and are carried from flower to flower as he flies about in search of nectar. Indeed, of all the beautiful and ingenious devices by which cross pollination is accomplished by animate beings, so far as known, *Yucca is the only case where this apparently intelligent pollination occurs. In all other cases it is accidental.*

Similar cases of apparently intelligent action among insects frequently occur, where food is provided beforehand for the larvæ. Such illustrations are the collecting of honey, the storing up of insects and spiders which have been killed for the purpose, or the laying of eggs in a branch or fruit stem which is afterwards girdled to provide dried material for the larval development. Between all of these devices, however, and Yucca pollination, there is, it appears to me, a wide difference. Such devices are the *inherited resultants* of easily understood facts or laws. The difference is merely a difference of degree truly. Such a difference as exists between the trained botanist and the rude understanding of the native American. The latter would understand that a girdled limb would in all probability die. Such things even his dull intellect will notice, as illustrations occur every day before his eyes. He could hardly be made to understand, however, that there is such a thing as sex in plants, although illustrations demonstrating this occur just as commonly under his eye. The nature of the problem is different. I do not credit the Yucca moth with a full understanding of what she is doing but it does seem that either she or her ancestors must have had some idea of what was being accomplished. The point here seized upon and utilized in the development by natural selection is so different from those usually utilized. The points usually developed into permanent habits by natural selection and inheritance are, commonly occurring, easily understood laws. I, however, surely believe with Riley and others that this perfect adaptation of Yucca and *Pronuba* must be the result of natural selection, the gradual modification of some archetypal form.

However this development took place, one watching *Pronuba's* actions at the present time, so full of purpose and understanding, can hardly fail to conclude with Riley that it is not "blind instinct" alone that guides her.—H. J. WEBBER, *Shaw School of Botany.*

ZOOLOGY.

Trematodes.—All authors agree that Trematodes are provided with a superficial cuticle which is pierced by numerous minute canals, but their statements in regard to the origin of this cuticle are very contradictory. Thus Ziegler looks upon the cuticle as a metamorphosed epithelium, Schneider and Minot consider it the basal membrane of an epithelium which has been lost in the parasitic life of the worm, while Leuckart describes it as a product of the subcuticula. To these three theories Dr. Brandes, of Halle, now adds a fourth[1] of which the following is a brief resumé:

Trematodes do not possess any subcuticula in the true sense of the word; the subcuticula described by Leuckart and others is parenchymatic tissue which, together with a similar tissue found between the muscles, Brandes names ectoparenchym, to distinguish it from the endoparenchym, *i. e.*, the parenchym in which the genital organs are imbedded; *there is, however, a true cuticle present, which is a product of the subcuticular glands;* the cuticle is not pierced by canals.—C. W. STILES.

Fishes of Ohio.—Oberlin College has begun the publication of a "Laboratory Bulletin." The second number, which has just appeared, contains a "Descriptive list of the fishes of Lorain county, Ohio," by the museum assistant, Lewis M. McCormick. In all 89 species are enumerated, and *Etheostoma wrighti* is described as new.

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[1] G. Brandes, Zum feineren Bau der Trematoden, Zeitschrift f. w. Zool., 1892, Bd. liii, 4.